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ABSTRACT

The study contains a total of 44 inservice or practicing teachers who were enrolled in professional development courses. A novel survey was created to determine a teacher's perspective of his/her school culture, as well as to measure a teacher's science achievement, math achievement, science self-efficacy, and math self-efficacy. The survey was administered at the beginning and end of the Physics and Integrated Math and Science Methods courses. Results show the changes of math and science self-efficacy beliefs and school culture beliefs. At the end of the Physics and Integrated Science and Math Methods courses, the inservice teachers believed they could motivate students to enjoy math/science, and the teachers also felt competent to answer questions about math/science experiments. The inservice teachers felt they could assist their colleagues with their math/science skills and the teachers felt they could reduce school absenteeism. The practicing teachers believed they could plan a math/science lesson using constructivist techniques and felt competent in their math/science achievements. The inservice teachers believed they could make the school a safe place, enhance collaboration with administrators to make the school operate effectively, motivate students to do well in school, and make the school a positive place to work. (KHR)

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The Influence of Self-Efficacy on School Culture, Science Achievement, and Math Achievement among Inservice Teachers

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Abstract

The study contained a total of 44 practicing teachers who were enrolled in two separate courses. The first set of 21 inservice teachers were involved in a professional development course titled "Physics with Toys," that met every day (Monday to Friday) during a three week period. The other class titled "Integrated Science and Math Methods" contained 23 practicing teachers who met for eight Saturdays during the fall semester. A novel survey was created to determine a teacher's perspective of his/her school culture, as well as to measure a teacher's science achievement, math achievement, science self-efficacy, and math self-efficacy (Bandura, 1995). The survey contained six demographic questions, nine school culture questions, five math achievement questions, five science achievement questions, five math self-efficacy questions, and five science self-efficacy questions. The survey was administered at the beginning and end of the Physics and Integrated Math and Science Methods courses. The data from the study was analyzed using a paired t-test to determine the differences in the pretest and posttest data.

Math and science self-efficacy beliefs and school culture beliefs changed by the end of the hands-on Physics and Integrated Science and Math Methods class. The inservice teachers felt they could assist their colleagues with their math/science skills and the teachers felt they could reduce school absenteeism. The practicing teachers believed they could plan a math/science lesson using constructivistic techniques and felt competent in their math/science achievements. The inservice teachers believed they could make the school a safe place, enhance collaboration with administrators to make the school operate effectively, motivate students to do well in school, and most importantly, the teachers felt they could help to make the school a positive place to work. As related to using cooperative learning groups, the teachers were prepared to teach math/science using hands-on techniques. At the end of the Physics and Integrated Science and Math Methods courses the inservice teachers believed they could motivate students to enjoy math/science, and the teachers also felt competent to answer questions about math/science experiments.

Theoretical Perspectives

School culture is the impression that one gets from visiting in a school. It is commonly associated with the collegiality of the teachers, staff, and students. There is usually an up-beat and rather happy sense of safety and caring within a school that has a positive school culture (Prosser, 1999). This caring atmosphere embraces the teachers, students, staff, and administrators as well as the physical dynamics in the school.

School culture is perceived to be the shared perceptions of all stakeholders in the school (McEvoy & Welker, 2000). It is not an individual's reaction to an event nor is it affected by daily events (Sutton and Fall, 1995). These shared perceptions are persistent and enduring.

Esposito (1999) found that peer mentoring had a positive effort on achievement. Felsen (1984) found, in a longitudinal study in Kentucky, that peers who assisted other peers in a small group setting created an enhanced sense of self-efficacy. Reavis, Vinson, and Fox (1999) found that positive school culture could be instilled through strong leadership, a caring environment, and committed personnel. Reavis et al. (1999) believed that school personnel who valued success also stressed the satisfactory completion of all tasks and encouraged hard work. Reavis et al. (1999) also states that believing in one's self and building realistic aspirations could develop a positive school culture in a short period of time. This tends to be strongly related to self-efficacy.

When discussing achievement it is important to describe the work of Piaget (1967 and 1973) given the fact that in order to achieve in math and science one must have engaged problem solving abilities. According to Piaget (1967) adolescents are capable of abstract thought or "formal" and "hypothetico-deductive" thinking (p. 62). Taking Piaget's (1967 and 1973) theory into account, in order for advanced problem-solving to occur a person must be operating at the formal level of thought. The same is true when discussing adult math and science achievement. The inservice teacher should have the cognitive background to solve problems that engage "formal" thinking.

Along with the area of school culture is the topic of self-efficacy. Bandura (1995) believed

that "self-efficacy is concerned with people's beliefs in their capabilities to produce given attainments" (p.1). Bandura and Walters (1959) were the most noted persons to examine and create a social learning theory related to aggression and, in their latter works, coined the term "self-efficacy." In an examination of Bandura's (1977) and Sears' (1951) theory, Grusec (1992) found that "beliefs about self-efficacy arise from the individual's history of achievement, . . . from observations of what others are able to accomplish, . . . attempts of others to mold feelings of self-efficacy through persuasion, and from consideration of one's own physiological state" (p.785).

Bruning, Schraw, and Ronning (1999) described teachers with high personal teaching efficacy. The classroom climate of a teacher with high personal teaching efficacy is characterized as allowing low achievers more time for achievement of goals, praising all students rather than criticizing, and the incorporation of effective classroom management. These teachers increased student learning through an attitude of acceptance for their students and their ideas (Bruning et al., 1999).

If a teacher has low self-efficacy in the area of science or math and does not feel competent in science or math, this may affect the overall culture of the classroom. Yager (2000) states that elementary school teachers are not content specialists and are generally responsible for all subject areas in grades K-8. Funding has been provided since the early eighties to target science and mathematics teachers both inservice and preservice teaching. The goal of this funding, and subsequent increase in funding, has been to make sure that teachers are prepared to teach science to the students in grades K-12. The National Science Education Standards released four goals of science education in grades K-12. These goals are: (1) to make sure students understand and experience the excitement of the natural world, (2) to use scientific processes to make decisions, (3) to be able to speak intellectually on scientific and technological topics, and (4) to increase their contribution to society by knowing, understanding, and being able to perform scientific skills (Yager, 2000).

Similarly, in a response to the call for reform in the teaching and learning of mathematics from the National Commission on Excellence in Education's 1983 publication, *A Nation at Risk*, The National Council of Teachers of Mathematics (NCTM) designated five general goals for all students of mathematics. NCTM first published the five goals in the *Curriculum and Evaluation Standards for School Mathematics* in 1989. NCTM's goals delineate that all students: (1) learn to value mathematics, (2) become confident in their ability to do mathematics, (3) become mathematical problem solvers, (4) learn to communicate mathematically, and (5) learn to reason mathematically (NCTM, 1989).

Yager (2000) states, "Teachers have an opportunity to cultivate and nourish their students' innate curiosity about the world" (p. 2). Math and science teachers must find ways to teach students in the classroom that actively involves and challenges the students. The goals listed above help in diminishing a teacher's own misconceptions and aid the teacher to assist students in applying scientific knowledge and skills. In this type of school culture, a teacher must be given opportunities to learn because so much information is changing and being acquired by the scientific community (Yager, 2000).

In order to fully understand the relationship between self-efficacy, achievement, and school culture it is necessary to study three main implications for science teachers as described by Jinks, Lorsbach, and Morey (2000). These are: (1) that the science curriculum will be impacted, (2) that the mode of instruction will be impacted, and (3) that the forms of assessment will be impacted (Jinks et al. 2000). According to Jinks et al. (2000) the teacher needs to make sure there are small, separate positive learning experiences for the students that gradually increase in difficulty. This is opposed to the more traditional approach of presenting a larger concept and then breaking apart the ideas from the top. Jinks et al. (2000) believes that self-efficacy will be enhanced if learning experiences ascend in difficulty and sequence.

Jinks et al. (2000) have listed some suggestions on how teachers can increase self-efficacy and, ultimately, student autonomy. They are (1) provide opportunities to reflect on and assess how

the students perform in science and identify criteria that students may believe affects their learning, (2) develop more problem-solving lessons, (3) ask the students to contribute to what they want in the science curriculum, (4) make sure lessons contribute to lifelong learning instead of being busywork, (5) provide opportunities for the students to collaborate, and (6) encourage more small group activities and individualized instruction (Jinks et al. 2000).

It is also important for a teacher to reflect upon the school culture and level of self-efficacy. The teachers may want to evaluate their students' self-efficacy beliefs by soliciting the following information: (1) ask how well the students expect to perform in science, (2) ask if the students feel confident in their understanding and fully know what they have learned, and (3) ask if they think they are able to learn science (Jinks et al. 2000). Jinks et al. (2000) cautions that students should always be able to give reasons and rationalizations for why they have such specific beliefs. Jinks et al. (2000) cites Bandura (1986) as having said that people will often change how they feel after they have reflected on their behavior and thinking. Jinks et al. (2000) states that if students with low self-efficacy are not allowed to revise their thoughts on science achievement then their self-efficacy will not change.

Gallagher (2000) discusses the idea of teaching for application of science knowledge and believes that teachers have little knowledge related to the application of science knowledge and do not include applications of scientific thought in their lessons. Teachers are not able to assist students in making connections to the world around them (Gallagher, 2000). Gallagher (2000) recommends exposing teachers to research related to misconceptions so that more dialogue can occur in the classroom.

Gallagher (2000) proposes a model which deals with teaching for application and understanding. He says there are three main factors in this model: (1) acquiring a knowledge base, (2) promoting understanding of information and making connections among facts, and (3) searching for applications of the knowledge (Gallagher, 2000). He says that this does not imply that direct instruction is wrong; it merely did not take the students to a higher level of thinking

(Gallagher, 2000). He summarizes by saying that his model, like any other model, requires "considerable effort and much reflection and intellectual struggle" (Gallagher, 2000, p. 5).

Generally speaking the findings discussed in the literature review related to science achievement and science teachers is similar to that of math achievement and math teachers. Historically women are still in the minority in relation to the number of jobs obtained in the area of math and engineering (Steele, 1997). Typically, female college students gravitate to college majors outside the fields of mathematics and science (Sherman, 1982). Such a change is noticed in high school and continues in college throughout one's life (Hyde, Fennema, and Lamon, 1990). This trend is also consistent with the number of women who are math teachers and math professors.

Given the information cited in the literature review, this research has one overall question. The research question is, "What is the influence of self-efficacy on school culture, science achievement, and math achievement among inservice teachers?" The purpose of this research is to determine if there is a relationship between self-efficacy, school culture, math achievement, and science achievement.

Research Methods and Data Source

The study contained a total of 44 practicing teachers who were enrolled in two separate courses. The first set of 21 participants were involved in a professional development course that met every day (Monday to Friday) during a three week period. This three credit course was titled "Physics with Toys" and was designed to alleviate Physics phobia among elementary school teachers. Using toys and other familiar household materials, Newtonian principles were applied within the class design. Motion and force were integral parts of the course content. Electricity and magnetism rounded out the wave phenomena. Through the use of simple math and simple objects, teachers learned the physics behind everyday objects and toys. The main goal of the course was to increase the teachers math and science competence as related to the area of physics through the use of hands-on techniques. The other class titled "Integrated Science and Math Methods" contained

23 practicing teachers who met for eight Saturdays during the fall semester. This course was developed according to recommendations made by the National Science Teacher Association (NSTA) and the National Council of Teachers of Mathematics (NCTM). Math cannot be taught effectively in isolation and a large portion of science involves math skills to complete activities and report results. In math and science the computation skills, geometry skills, graphing, problem solving skills, working with equations, probability, and percentages are integral parts of many, or most, science lessons. An overall goal of this course was to apply requisite skills of math to hands-on activities which will, in turn strengthen a learner's mathematical ability and hopefully make science more meaningful.

A novel survey was created to determine a teacher's perspective of his/her school culture, as well as to measure a teacher's science achievement, math achievement, science self-efficacy, and math self-efficacy (Bandura, 1995). The survey contains six demographic questions, nine school culture questions, five math achievement questions, five science achievement questions, five math self-efficacy questions, and five science self-efficacy questions. The survey was administered at the beginning and end of the Physics and Integrated Math and Science Methods courses. The data from the study was analyzed using a paired t-test to determine the differences in the pretest and posttest data.

Results

After analyzing the data, significant changes occurred between the pretest and posttest data. There were significant changes in self-efficacy beliefs and prominent changes in achievement after the hands-on Physics and Integrated Science and Math Methods classes were finished. Taking into account the five math achievement questions, there was an increase in the percent correct for each of these questions. There was also an increase in science achievement for three of the five science questions (Refer to Figure 1).

Figure 1

Achievement - Valid Percentage Correct

Question	Pretest	Posttest
restitution	26.8	9.8
polymers	76.7	46.3
energy	54.5	100.0
quanta	19.0	95.2
polarity	34.9	95.1
rate	86.4	100.0
dog show	76.7	97.6
Fibbonacci	35.7	95.2
big numbers	00.0	81.0
vertices	26.2	95.2

Math and science self-efficacy beliefs and school culture beliefs also changed at the end of the hands-on Physics and Integrated Science and Math Methods class. The inservice teachers felt they could assist their colleagues with their math and science skills [t(40)=8.26<.01] and the teachers felt they could reduce school absenteeism [t(40)=9.29<.01]. The teachers also believed they could plan a science lesson [t(40)=8.16<.01] and math lesson [t(40)=7.30<.01] using constructivistic techniques. The practicing teachers felt competent in their science achievements [t(40)=7.84<.01] and math achievements [t(40)=6.56<.01].

The inservice teachers believed they could make the school a safe place [t(41)=5.05<.01], enhance collaboration with administrators [t(40)=6.47<.01] make the school operate effectively, and motivate students to do well in school [t(39)=5.92<.01]. Most importantly, the teachers felt they could help make the school a positive place to work [t(40)=4.43<.01].

As related to using cooperative learning groups, the teachers were prepared to teach science using hands-on techniques [t(40)=5.70<.01] and prepared to teach math using hands-on manipulatives [t(40)=6.30<.01]. At the end of the Physics and Integrated Science and Math Methods courses the inservice teachers believed they could motivate students to enjoy science [t(40)=6.02<0.1] and math [t(40)=5.54 <.01], as well as the teachers felt competent to answer questions about science experiments [t(40)=6.10<.01] and math experiments [t(40)=5.52<.01].

The data that was not significant is also worth documenting. The teachers felt they were unable to help the students enjoy school or help the students trust the teacher.

Discussion

As the clarion call resounds across America and is heard in every country of the world, educators are scrambling to develop strategies to ensure student and teacher safety. Bandura (1986) suggested that a social cognitive theory, which he named "self-efficacy," was a contributing factor in the lessening of violence and antisocial behavior. Since that time, a dedicated endeavor has ensued to discover what effect self-efficacy has on schools, students, and teachers.

This study has shown that a positive sense of self-efficacy including a positive teaching self-efficacy, will affect math and science achievement, and tends to develop positive social interactions. When the faculty in a school begin to build or enhance a positive self-efficacy through the use of group work, peer tutoring, modeling, self-reflection, and self-talk, then the atmosphere in the classroom begins to change. This change begins a rippling effect throughout the school. A positive school climate is perceived by all who enter the school, and to affect this process requires training in all areas of education.

The research was conducted in a rural area of Appalachia in the midst of poverty and apathy toward education. It is resoundingly significant in the changes noted from pretesting to posttesting among these teachers. Teachers were chosen by the researchers because they will be in the "front trenches" in this fight against apathy, violence, and poor achievement. When a teacher can see the results by actually participating in the process, then there is a greater likelihood that the teacher will implement the program. Since teachers serve as role models to many students, they need to be firmly convinced that they are important to society.

Despite calls for reform in the teaching of mathematics throughout the 20th century, the central instructional process has remained unchanged (Hiebert, 1997). Most recently, the video component of the Third International Mathematics and Science Study (TIMSS) demonstrates that

instruction followed the consistent pattern reported by Stevens in the 1920's, Case and Easley in the 1970's, and Stodolsky in the 1980's. The typical class began with a review of homework given the day before, a demonstration of a new procedure, followed by seatwork designed to allow students to practice the procedure, and finally assigned more practice for homework (Hiebert, 1997). As a result of this study, Hiebert (1997) reported to Congress that the quality of American lessons were poor; instruction emphasized skills and were devoid of activities requiring students to draw logical conclusions through deductive reasoning.

The 1993 National Survey of Science and Mathematics Education found that most elementary teachers reported teaching mathematics and science in self-contained classrooms for less than an hour per day (Weiss, 1994). Nearly 40% of the teachers stated they gave heavy emphasis to preparing students for standardized tests that focused on lower level knowledge skills rather than on higher order thinking skills (Madaus, West, Harmon, Lomax, and Vistor, 1992). When asked what strategies should be included in mathematics and science instruction, more than 95% of teachers in grades one through four reported believing that activities should include: hands-on/manipulative activities, be applicable to the students' daily lives, provide concrete experiences before abstract treatments and every student should study mathematics and science every year. Ninety-two percent of the teachers reported that cooperative learning groups should be used in mathematics and science instruction.

Several factors may have attributed to the change in the instructional methods of the teachers. First, this study demonstrates that when teachers are provided with professional development designed to increase the teachers' competence in mathematics and science changes in their instruction do occur. These changes may be due to the increased confidence or efficacy of the teachers in their ability to understand concepts in mathematics and science. Another possible factor that may have provided the stimulus for teachers to change their instructional methods could be the positive social interactions or teachers networking with other teachers. Teachers developed or

solidified collegial relationships with teachers from their county as well as teachers from other area schools.

Conclusion

This research was a study to determine any significant differences between the variables of school culture, self-efficacy, and achievement in science and math among inservice teachers. There was significance in the pretest and posttest data concerning math and science achievement. One possible problem was the lack of progress in the question relating to restitution. It became quite evident that the Theory of Restitution and the idea of Transfer of Energy were confused. Polymers and monomers were also confused. Possibly, more time by the instructors should have been spent on these topics to ensure full understanding of the concept.

Of importance to the educational community is the result of the analysis that demonstrates that a constructivist theory of learning and teaching can produce results. Constructivism must be used in an environment that is motivating to the learners and is carried out in cooperative groups whenever possible (Phye, 1997). Since self-efficacy has been associated with self-confidence and self-esteem, and school culture is regarded as the perception one develops when in a school, there is good reason to fully accept the theory behind this research that self-efficacy among teachers and students will be evidenced in a school that embodies a positive school culture. Felsen (1984) presented research that postulated the beliefs that self-efficacy was not related to gender, socioeconomic status, race, creed, nor culture. Instead, his longitudinal study in Kentucky demonstrated that students with a positive sense of self-efficacy tended to come to school more regularly, participated in school disruptions less often, have their homework more regularly, and were more social than most students of the same age. If school culture embodies a sense of collegiality among faculty, staff, and administration, according to the research done by Reavis et al (1999), then one approach to increase the sense of a functioning school culture is to increase self-efficacy.

Although more research is needed to verify the findings, there is strong evidence to support the assumption that self-efficacy and the development of a strong sense of positive self-efficacy can have an affect on students, teachers, and a positive school culture. If you have spent time in a public school, a positive school culture is obligatory to a feeling of satisfaction in the school system by parents. We all know the positive feeling of being in a warm and inviting school and, adversely, the uncomfortable feeling of being in a cold and uninviting school.

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